Chapter 5

Graphing

Sections 5-1 and 5-2 of this chapter provide basic information you need to know in order to draw a graph. The remaining sections describe more advanced graphing features and functions.

Select the icon in the Main Menu that suits the type of graph you want to draw or the type of table you want to generate.

- **GRPH·TBL** … General function graphing or number table generation
- **CONICS** … Implicit function graphing (5-1-5 ~ 5-1-6, 5-11-17~5-11-21)
- **RUN·MAT** … Manual graphing (5-6-1 ~ 5-6-4)
- **DYNA** … Dynamic Graph (5-8-1 ~ 5-8-6)
- **RECUR** … Recursion graphing or number table generation (5-9-1 ~ 5-9-8)

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5-1 Sample Graphs

■ How to draw a simple graph (1)

Description

To draw a graph, simply input the applicable function.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.

Execution

2. Input the function you want to graph.
   Here you would use the V-Window to specify the range and other parameters of the graph. See 5-2-1.
3. Draw the graph.

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Example **To graph $y = 3x^2$**

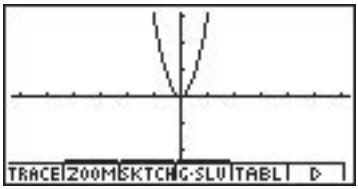
Procedure

① [MENU] GRPH • TBL

② [3] [X,θ,T] [x^2] [EXE]

③ [F5] (DRAW) (or [EXE])

Result Screen



■ How to draw a simple graph (2)

Description

You can store up to 20 functions in memory and then select the one you want for graphing.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.

Execution

2. Specify the function type and input the function whose graph you want to draw.

   You can use the GRPH • TBL Mode to draw a graph for the following types of expressions: rectangular coordinate expression, polar coordinate expression, parametric function, X = constant expression, inequality.

   F3 (TYPE) 1 (Y =) ... rectangular coordinates
   2 (*r* =) ... polar coordinates
   3 (Param) ... parametric function
   4 (X = c) ... X = constant function
   5 (INEQUA) 1 (Y>)~ 4 (Y≦) ... inequality

   Repeat this step as many times as required to input all of the functions you want.

   Next you should specify which of the functions among those that are stored in memory you want to graph (see 5-3-4). If you do not select specific functions here, the graph operation will draw graphs of all the functions currently stored in memory.

3. Draw the graph.

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Example **Input the functions shown below and draw their graphs**
Y1 = $2x^2 - 3$, $r2 = 3\sin 2\theta$

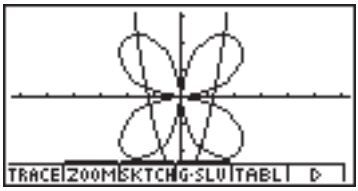
Procedure

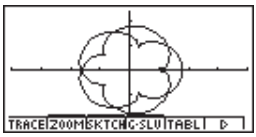
① MENU GRPH•TBL

② F3(TYPE) 1 (Y=) 2 X,θ,T x^2 − 3 EXE
F3(TYPE) 2 (r=) 3 sin 2 X,θ,T EXE

③ F5(DRAW)

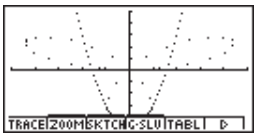
Result Screen





(Param)

(INEQUA)



(Plot)

■ How to draw a simple graph (3)

Description

Use the following procedure to graph the function of a parabola, circle, ellipse, or hyperbola.

Set Up

1. From the Main Menu, enter the CONICS Mode.

Execution

2. Use the cursor ▲▼ keys to specify one of the function type as follows.

Graph Type	Function
Parabola	$X = A(Y - K)^2 + H$ $X = AY^2 + BY + C$ $Y = A(X - H)^2 + K$ $Y = AX^2 + BX + C$
Circle	$(X - H)^2 + (Y - K)^2 = R^2$ $AX^2 + AY^2 + BX + CY + D = 0$
Ellipse	$\frac{(X - H)^2}{A^2} + \frac{(Y - K)^2}{B^2} = 1$
Hyperbola	$\frac{(X - H)^2}{A^2} - \frac{(Y - K)^2}{B^2} = 1$ $\frac{(Y - K)^2}{A^2} - \frac{(X - H)^2}{B^2} = 1$

3. Input values for the required variables.
4. Graph the function.

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Example **Graph the circle $(X-1)^2 + (Y-1)^2 = 2^2$**

Procedure

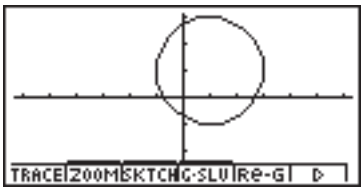
① MENU CONICS

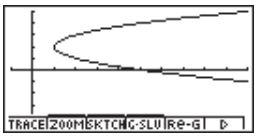
② ▼ ▼ ▼ ▼ EXE

③ 1 EXE 1 EXE 2 EXE

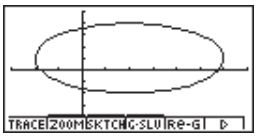
④ F6 (DRAW)

Result Screen

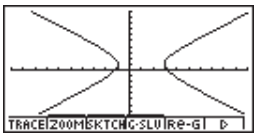




(Parabola)



(Ellipse)



(Hyperbola)

5-2 Controlling What Appears on a Graph Screen

■ V-Window (View Window) Settings

Use the View Window to specify the range of the x- and y-axes, and to set the spacing between the increment on each axis. You should always set the V-Window parameters you want to use before graphing.

• To make V-Window settings

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Press [SHIFT] [OPTN] (V-Window) to display the V-Window setting screen.

Rectangular coordinate parameter

Xmin … Minimum x-axis value

Xmax … Maximum x-axis value

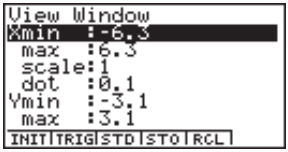
Xscale … Spacing of x-axis increments

Xdot … Value that corresponds to one x-axis dot

Ymin … Minimum y-axis value

Ymax … Maximum y-axis value

Yscale … Spacing of y-axis increments



Polar coordinate parameter

Tθmin ... T, θ minimum values

Tθmax ... T, θ maximum values

Tθptch ... T, θ pitch

3. Press ▼ to move the highlighting, and input an appropriate value for each parameter, pressing [EXE] after each.
   - {**INIT**}/{**TRIG**}/{**STD**} … V-Window {initial settings}/{initial settings using specified angle unit}/{standardized settings}
   - {**STO**}/{**RCL**} … V-Window setting {store}/{recall}

After settings are the way you want them, press [ESC] or [SHIFT] [ESC] (QUIT) to exit the V-Window setting screen.*1

*1 Pressing [EXE] without inputting anything while ■ is displayed exits the View Window setting screen.

• V-Window Setting Precautions

- Inputting zero for Tθ ptch causes an error.
- Any illegal input (out of range value, negative sign without a value, etc.) causes an error.
- An error occurs when Xmax is less than Xmin, or Ymax is less than Ymin. When Tθ max is less than Tθ min, Tθ ptch becomes negative.
- You can input expressions (such as 2π) as V-Window parameters.
- When the V-Window setting produces an axis that does not fit on the display, the scale of the axis is indicated on the edge of the display closest to the origin.
- Changing the V-Window settings clears the graph currently on the display and replaces it with the new axes only.
- Changing the Xmin or Xmax value causes the Xdot value to be adjusted automatically. Changing the Xdot value causes the Xmax value to be adjusted automatically.
- A polar coordinate (r =) or parametric graph will appear coarse if the settings you make in the V-Window cause the T, θ pitch value to be too large, relative to the differential between the T, θ min and T, θ max settings. If the settings you make cause the T, θ pitch value to be too small relative to the differential between the T, θ min and T, θ max settings, on the other hand, the graph will take a very long time to draw.
- The following is the input range for V-Window parameters.

  -9.999999999_{E} 97 to 9.999999999_{E} 97

■ Initializing and Standardizing the V-Window

• To initialize the V-Window

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Press SHIFT OPTN (V-Window).
   This displays the V-Window setting screen.
3. Press F1 (INIT) to initialize the V-Window.

Xmin = –6.3,	Xmax = 6.3,	Xscale = 1	Xdot = 0.1
Ymin = –3.1,	Ymax = 3.1,	Yscale = 1	
Tθ min = 0,	Tθ max = 2π (rad),	Tθ ptch = 2π /60 (rad)	

• To initialize the V-Window in accordance with an angle unit

In step 3 of the procedure under "To initialize the V-Window" above, press F2 (TRIG) to initialize the V-Window in according with an angle unit.

Xmin = –3π (rad),	Xmax = 3π (rad),	Xscale = π /2 (rad),	Xdot = π /21 (rad),
Ymin = –1.6,	Ymax = 1.6,	Yscale = 0.5	

• To standardize the V-Window

The following are the standard V-Window settings of this calculator.

Xmin = –10,	Xmax = 10,	Xscale = 1,	Xdot = 0.15873015,
Ymin = –10,	Ymax = 10,	Yscale = 1,	
Tθ min = 0,	Tθ max = 2π (rad),	Tθ ptch = 2π /60 (rad)	

In step 3 of the procedure under "To initialize the V-Window" above, press F3 (STD) to standardize V-Window settings in accordance with the above.

Initialization and standardization cause Tθ min, Tθ max, Tθ ptch values to change automatically in accordance with the current angle unit setting as shown below.

Deg Mode:
Tθ min = 0, Tθ max = 360, Tθ ptch = 6

Gra Mode:
Tθ min = 0, Tθ max = 400, Tθ ptch = 400/60

■ V-Window Memory

You can store up to six sets of V-Window settings in V-Window memory for recall when you need them.

• To store V-Window settings

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Press [SHIFT] [OPTN] (V-Window) to display the V-Window setting screen, and input the values you want.
3. Press [F4] (STO) to display the pop-up window.
4. Press a number key to specify the V-Window memory where you want to save the settings, and then press [EXE]. Pressing [1] [EXE] stores the settings in V-Window Memory 1 (V-Win1).

• To recall V-Window memory settings

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Press [SHIFT] [OPTN] (V-Window) to display the V-Window setting screen.
3. Press [F5] (RCL) to display the pop-up window.
4. Press a number key to specify the V-Window memory number for the settings you want to recall, and then press [EXE]. Pressing [1] [EXE] recalls the settings in V-Window Memory 1 (V-Win1).

Storing V-Window settings to a memory that already contains setting data replaces the previous data with the new settings.

Recalling settings causes the current V-Window settings to be replaced with those recalled from memory.

■ Specifying the Graph Range

Description

You can define a range (start point, end point) for a function before graphing it.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Make V-Window settings.

Execution

3. Specify the function type and input the function. The following is the syntax for function input.

   Function ▶ SHIFT + ([ )Start Point ▶ End Point SHIFT − ( ])
4. Draw the graph.

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Example **Graph $y = x^2 + 3x - 2$ within the range $-2 \leqq x \leqq 4$**

Use the following V-Window settings.

Xmin = –3, Xmax = 5, Xscale = 1

Ymin = –10, Ymax = 30, Yscale = 5

Procedure

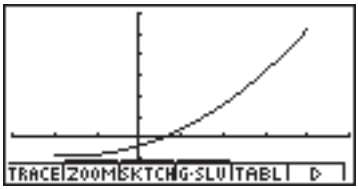
① MENU GRPH•TBL

② SHIFT OPTN (V-Window) (–) 3 EXE 5 EXE 1 EXE ▼
(–) 1 0 EXE 3 0 EXE 5 EXE ESC

③ F3 (TYPE) 1 (Y=) X,θ,T x^2 + 3 X,θ,T − 2 ▶
SHIFT + ([ ) (–) 2 , 4 SHIFT − ( ]) EXE

④ F5 (DRAW)

Result Screen



You can specify a range when graphing rectangular expressions, polar expressions, parametric functions, and inequalities.

■ Zoom

Description

This function lets you enlarge and reduce the graph on the screen.

Set Up

1. Draw the graph.

Execution

2. Specify the zoom type.

F2 (ZOOM) 1 (Box) ... Box zoom
Draw a box around a display area, and that area is enlarged to fill the entire screen.

2 (Factor)

3 (In)/ 4 (Out) ... Factor zoom
The graph is enlarged or reduced in accordance with the factor you specify, centered on the current pointer location.

5 (Auto) ... Auto zoom
V-Window y-axis settings are automatically adjusted so the graph fills the screen along the y-axis.

6 (Orig) ... Original size
Returns the graph to its original size following a zoom operation.

7 (Square) ... Graph correction
V-Window x-axis values are corrected so they are identical to the y-axis values.

8 (Rnd) ... Coordinate rounding
Rounds the coordinate values at the current pointer location.

9 (Intg) ... Integer
Each dot is given a width of 1, which makes coordinate values integers.

X,θ,T (Pre) ... Previous
V-Window parameters are returned to what they were prior to the last zoom operation.

log (QUICK) ... Quick zoom
Redraws the graph in accordance with the settings stored in a selected V-Window memory.

Box zoom range specification

3. Use the cursor keys to move the pointer (✛) in the center of the screen to the location where you want one corner of the box to be, and then press EXE.
4. Use the cursor keys to move the pointer. This causes a box to appear on the screen. Move the cursor until the area you want to enlarge is enclosed in the box, and then press EXE to enlarge it.

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Example **Graph $y = (x + 5)(x + 4)(x + 3)$, and then perform a box zoom.**

Use the following V-Window settings.

Xmin = −8, Xmax = 8, Xscale = 2

Ymin = −4, Ymax = 2, Yscale = 1

Procedure

① MENU GRPH•TBL

SHIFT OPTN (V-Window) (↔) 8 EXE 8 EXE 2 EXE (▼)

(↔) 4 EXE 2 EXE 1 EXE ESC

F3 (TYPE) 1 (Y=) (X,θ,T + 5) (X,θ,T + 4)

(X,θ,T + 3) EXE

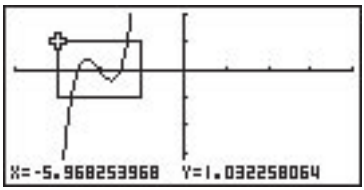
F5 (DRAW)

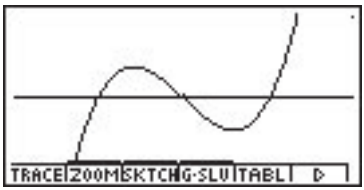
② F2 (ZOOM) 1 (Box)

③ ◀~◀ EXE

④ ◀~◀, ▲~▲ EXE

Result Screen





You cannot specify the same point for and you cannot specify a straight line for the box zoom box.

■ Factor Zoom

Description

With factor zoom, you can zoom in or out, centered on the current cursor position.

Set Up

1. Draw the graph.

Execution

2. Press [F2] (ZOOM) [2] (Factor) to open a pop-up window for specifying the x-axis and y-axis zoom factor. Input the values you want and then press [ESC].
3. Press [F2] (ZOOM) [3] (In) to enlarge the graph, or [F2] (ZOOM) [4] (Out) to reduce it. The graph is enlarged or reduced centered on the current pointer location.
4. Use the cursor keys to move the cursor to the point upon which you want the zoom operation to be centered, and then press [EXE] to zoom.

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Example **Enlarge the graphs of the two expressions shown below five times on both the x-and y-axis to see if they are tangent.**
Y1 = $(x + 4)(x + 1)(x - 3)$, Y2 = $3x + 22$

Use the following V-Window settings.

Xmin = −8, Xmax = 8, Xscale = 1
Ymin = −30, Ymax = 30, Yscale = 5

Procedure

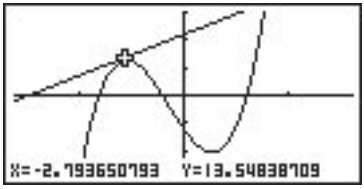
① MENU GRPH•TBL
SHIFT OPTN (V-Window) (−) 8 EXE 8 EXE 1 EXE ▼
(−) 3 0 EXE 3 0 EXE 5 EXE ESC
F3 (TYPE) 1 (Y=) (X,θ,T + 4) (X,θ,T + 1)
(X,θ,T − 3) EXE
3 X,θ,T + 2 2 EXE
F5 (DRAW)

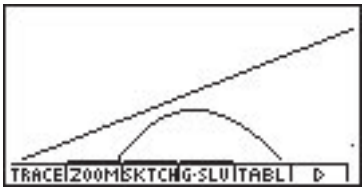
② F2 (ZOOM) 2 (Factor) 5 EXE 5 EXE ESC

③ F2 (ZOOM) 3 (In)

④ ▲~▲, ◀~◀ EXE

Result Screen

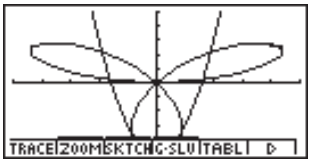


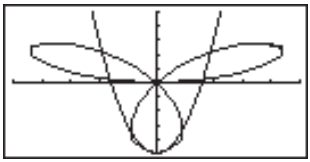


You can repeat factor zoom to enlarge or reduce a graph even further.

■ Turning Function Menu Display On and Off

Press [CTRL] [0] to toggle display of the menu at the bottom of the screen on and off.



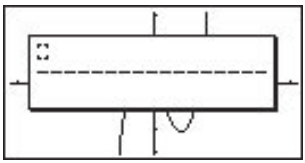


Turning off the funciton menu display makes it possible to view part of a graph hidden behind it. When you are using the trace function or other functions during which the function menu is normally not displayed, you can turn on the menu display to execute a menu command.

If a pull-up menu is open when you press [CTRL] [0] to turn off menu display, the pull-up menu remains on the screen.

■ About the Calc Window

Pressing [CTRL] [F4] (CAT/CAL) while a graph or number table is on the display opens the Calc Window. You can use the Calc Window to perform calculations with values obtained from graph analysis, or to change the value assigned to variable A in Y = AX and other expressions and then redraw the graph.



Press [ESC] to close the Calc Window.

After using the Calc Window to change the value of a variable connected with a graph or table, be sure to always execute [Re-G] (re-graph) or [Re-T] (re-calculate table). Doing so ensures that the displayed graph or table is current.
Calc Window cannot be used in the RUN • MAT Mode, while a program is running, or in combination with Dynamic Graph.
Calc Window cannot be used in combination with V-Window or the table range setting screen.
Complex number calculations cannot be performed on the Calc Window.

5-3 Drawing a Graph

You can store up to 20 functions in memory. Functions in memory can be edited, recalled, and graphed.

■ Specifying the Graph Type

Before you can store a graph function in memory, you must first specify its graph type.

1. While the Graph function list is on the display, press F6 (▷) F3 (TYPE) to display the graph type menu, which contains the following items.
   - {**Y=**}/{**r=**}/{**Param**}/{**X=c**} ... {rectangular coordinate}/{polar coordinate}/{parametric}/{X=constant}*1 graph
   - {**INEQUA**}
     - {**Y>**}/{**Y<**}/{**Y≥**}/{**Y≤**} ... {$Y>f(x)$}/{$Y<f(x)$}/{$Y\geqq f(x)$}/{$Y\leqq f(x)$} inequality graph
2. Press the number key that corresponds to the graph type you want to specify.

■ Storing Graph Functions

• To store a rectangular coordinate function (Y =) *2

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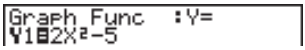
Example **To store the following expression in memory area Y1 : $y = 2x^2 - 5$**

F3 (TYPE) 1 (Y =) (Specifies rectangular coordinate expression.)

2 X,θ,T x^2 − 5 (Inputs expression.)

EXE (Stores expression.)



• To store a polar coordinate function (r =) *2

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Example **To store the following expression in memory area r2 : $r = 5\sin 3\theta$**

F3 (TYPE) 2 (r =) (Specifies polar coordinate expression.)

5 sin 3 X,θ,T (Inputs expression.)

EXE (Stores expression.)

*1 Attempting to draw a graph for an expression in which X is input for an X = constant expression results in an error.

*2 A function cannot be stored into a memory area that already contains a function of a different type from the one you are trying to store. Select a memory area that contains a function that is the same type as the one you are storing, or delete the function in the memory area to which you are trying to store.

• To store a parametric function *1

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Example **To store the following functions in memory areas Xt3 and Yt3 :**
x = 3 sin T
y = 3 cos T

F3 (TYPE) 3 (Param) (Specifies parametric expression.)

3 sin X,θ,T EXE (Inputs and stores x expression.)

3 cos X,θ,T EXE (Inputs and stores y expression.)

• To store an X = constant expression *2

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Example **To store the following expression in memory area X4 :**
X = 3

F3 (TYPE) 4 (X = c) (Specifies X = constant expression.)

3 (Inputs expression.)

EXE (Stores expression.)

• Inputting X, Y, T, r, or θ for the constant in the above procedures causes an error.

• To store an inequality *2

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Example **To store the following inequality in memory area Y5 :**
$y > x^2 - 2x - 6$

F3 (TYPE) 5 (INEQUA) 1 (Y>) (Specifies an inequality.)

X,θ,T x^2 − 2 X,θ,T − 6 (Inputs expression.)

EXE (Stores expression.)

*1 You will not be able to store the expression in an area that already contains a rectangular coordinate expression, polar coordinate expression, X = constant expression or inequality. Select another area to store your expression or delete the existing expression first.

*2 A function cannot be stored into a memory area that already contains a function of a different type from the one you are trying to store. Select a memory area that contains a function that is the same type as the one you are storing, or delete the function in the memory area to which you are trying to store.

■ Editing and Deleting Functions

• To edit a function in memory

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Example **To change the expression in memory area Y1 from $y = 2x^2 - 5$ to $y = 2x^2 - 3$**

▶ (Displays cursor.)

▶ ▶ ▶ ▶ DEL 3 (Changes contents.)

EXE (Stores new graph function.)

• To change the type of a function *1

1. While the Graph function list is on the display, press ▲ or ▼ to move the highlighting to the area that contains the function whose type you want to change.
2. Press F3 (TYPE) 6 (CONV).
3. Select the function type you to change to.

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Example **To change the function in memory area Y1 from $y = 2x^2 - 3$ to $y < 2x^2 - 3$**

F3 (TYPE) 6 (CONV) 3 (▶Y<) (Changes the function type to "Y<".)

• To delete a function

1. While the Graph function list is on the display, press ▲ or ▼ to move the highlighting to the area that contains the function you want to delete.
2. Press F2 (DEL) or DEL.
3. Press EXE (Yes) to delete the function for ESC (No) to abort the procedure without deleting anything.

*1 The function type can be changed for rectangular coordinate functions and inequalities only.

Parametric functions come in pairs (Xt and Yt). When editing a parametric function, clear the graph functions and re-input from the beginning.

■ Selecting Functions for Graphing

• To specify the draw/non-draw status of a graph

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Example **To select the following functions for drawing :**
Y1 = 2x^2 – 5, r2 = 5 sin3θ

Use the following V-Window settings.

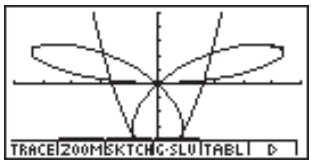
Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –5, Ymax = 5, Yscale = 1

Tθ min = 0, Tθ max = π, Tθ ptch = 2π / 60

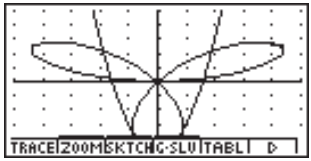
▼▼ (Select a memory area that contains a function for which you want to specify non-draw.)

F1 (SEL) (Specifies non-draw.)
F5 (DRAW) or EXE (Draws graphs.)



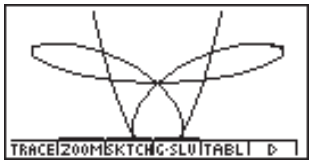
- Each press of F1 (SEL) toggles a graph between draw and non-draw.
- Pressing CTRL F5 (G↔T) or ESC returns to the Graph function list.
- You can use the SET UP screen settings to alter the appearance of the graph screen as shown below.
- Grid: On

  This setting causes dots to appear at the grid intersects on the display.



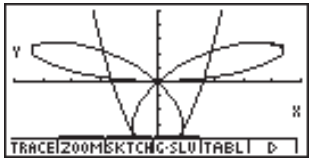
- Axes: Off

  This setting clears the axis lines from the display.



- Label: On

  This setting displays labels for the x- and y-axes.



■ Graph Memory

Graph memory lets you store up to 20 sets of graph function data and recall it later when you need it.

A single save operation saves the following data in graph memory.

- All graph functions in the currently displayed Graph function list (up to 20)
- Graph types
- Draw/non-draw status
- View Window settings (1 set)

• To store graph functions in graph memory

1. Press F5 (GMEM) 1 (Store) to display the pop-up window.
2. Press a number key to specify the Graph memory where you want to save the graph function, and then press EXE. Pressing 1 EXE stores the graph function to Graph Memory 1 (G-Mem1).
   - There are 20 graph memories numbered G-Mem1 to G-Mem20.

• To recall a graph function

1. Press F5 (GMEM) 2 (Recall) to display the pop-up window.
2. Press a number key to specify the Graph memory for the function you want to recall, and then press EXE. Pressing 1 EXE recalls the graph function in Graph Memory 1 (G-Mem1).

Storing a function in a memory area that already contains a function replaces the existing function with the new one.
If the data exceeds the calculator's remaining memory capacity, an error occurs.
Recalling data from graph memory causes any data currently on the Graph function list to be deleted.

5-4 Storing a Graph in Picture Memory

You can save up to 20 graphic images in picture memory for later recall. You can overdraw the graph on the screen with another graph stored in picture memory.

• To store a graph in picture memory

1. After graphing in GRPH•TBL Mode, press [F6] (▷) [F1] (PICT) [1] (Store) to display the pop-up window.
2. Press a number key to specify the Picture memory where you want to save the picture, and then press [EXE]. Pressing [1] [EXE] stores the picture function to Picture Memory 1 (Pict 1).

- There are 20 picture memories numbered Pict 1 to Pict 20.

• To recall a stored graph

1. After graphing in GRPH•TBL Mode, press [F6] (▷) [F1] (PICT) [2] (Recall) to display the pop-up window.
2. Press a number key to specify the Picture memory for the picture you want to recall, and then press [EXE]. Pressing [1] [EXE] recalls the picture function in Picture Memory 1 (Pict 1).

Storing a graphic image in a memory area that already contains a graphic image replaces the existing graphic image with the new one.

A dual Graph screen or any other type of graph that uses a split screen cannot be saved in picture memory.

5-5 Drawing Two Graphs on the Same Screen

■ Copying the Graph to the Sub-screen

Description

Dual Graph lets you split the screen into two parts. Then you can graph two different functions in each for comparison, or draw a normal size graph on one side and its enlarged version on the other side. This makes Dual Graph a powerful graph analysis tool.

With Dual Graph, the left side of the screen is called the “main screen,” while the right side is called the “sub-screen.”

- **Main Screen**
  The graph in the main screen is actually drawn from a function.
- **Sub-screen**
  The graph on the sub-screen is produced by copying or zooming the main screen graph. You can even make different V-Window settings for the sub-screen and main screen.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. On the SET UP screen, select G+G for Dual Screen.
3. Make V-Window settings for the main screen.
   Press [F6] (RIGHT) to display the sub-graph settings screen. Pressing [F6] (LEFT) returns to the main screen setting screen.

Execution

4. Store the function, and draw the graph in the main screen.
5. Perform the Dual Graph operation you want.
   [F4] (COPY) ... Duplicates the main screen graph in the sub-screen
   [F5] (SWAP) ... Swaps the main screen contents and sub-screen contents

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Example **Graph $y = x(x + 1)(x - 1)$ in the main screen and sub-screen.**

Use the following V-Window settings.

(Main Screen)

Xmin = −2, Xmax = 2, Xscale = 0.5

Ymin = −2, Ymax = 2, Yscale = 1

(Sub-screen)

Xmin = −4, Xmax = 4, Xscale = 1

Ymin = −3, Ymax = 3, Yscale = 1

Procedure

① MENU GRPH•TBL

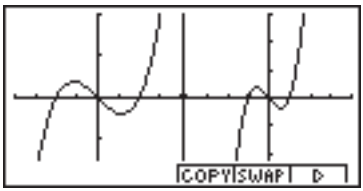
② CTRL F3(SET UP) ▼ ▼ ▼ F2(G+G) ESC

③ SHIFT OPTN(V-Window) (−) 2 EXE 2 EXE 0 • 5 EXE ▼
(−) 2 EXE 2 EXE 1 EXE
F6(RIGHT) (−) 4 EXE 4 EXE 1 EXE ▼
(−) 3 EXE 3 EXE 1 EXE ESC

④ F3(TYPE) 1(Y=) X,θ,T (X,θ,T + 1) (X,θ,T − 1) EXE
F5(DRAW)

⑤ F6(▷) F4(COPY)

Result Screen



■ Graphing Two Different Functions

Description

Use the following procedure to graph different functions in the main screen and sub-screen.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. On the SET UP screen, select G+G for Dual Screen.
3. Make V-Window settings for the main screen.

   Press F6 (RIGHT) to display the sub-graph settings screen. Pressing F6 (LEFT) returns to the main screen setting screen.

Execution

4. Store the functions for the main screen and sub-screen.
5. Select the function of the graph that you want to eventually have in the sub-screen.
6. Draw the graph in the main screen.
7. Swap the main screen and sub-screen contents.
8. Return to the function screen.
9. Select the function of the next graph you want in the main screen.
10. Draw the graph in the main screen.

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Example **Graph $y = x(x + 1)(x - 1)$ in the main screen, and $y = 2x^2 - 3$ in the sub-screen.**

Use the following V-Window settings.

(Main Screen)

Xmin = −4, Xmax = 4, Xscale = 1

Ymin = −5, Ymax = 5, Yscale = 1

(Sub-screen)

Xmin = −2, Xmax = 2, Xscale = 0.5

Ymin = −2, Ymax = 2, Yscale = 1

Procedure

① MENU GRPH•TBL

② CTRL F3 (SET UP) ▼ ▼ ▼ F2 (G+G) ESC

③ SHIFT OPTN (V-Window) (−) 4 EXE 4 EXE 1 EXE ▼
(−) 5 EXE 5 EXE 1 EXE
F6 (RIGHT) (−) 2 EXE 2 EXE 0 • 5 EXE ▼
(−) 2 EXE 2 EXE 1 EXE ESC

④ F3 (TYPE) 1 (Y=) X,θ,T (X,θ,T + 1) (X,θ,T − 1) EXE
2 X,θ,T x^2 − 3 EXE

⑤ ▲ ▲ F1 (SEL)

⑥ F5 (DRAW)

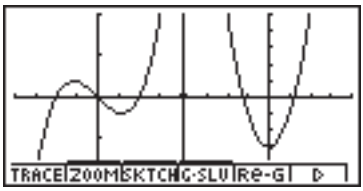
⑦ F6 (▷) F5 (SWAP)

⑧ ESC

⑨ F1 (SEL)

⑩ F5 (DRAW)

Result Screen



■ Using Zoom to Enlarge the Sub-screen

Description

Use the following procedure to enlarge the main screen graph and then move it to the sub-screen.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. On the SET UP screen, select G+G for Dual Screen.
3. Make V-Window settings for the main screen.

Execution

4. Input the function and draw the graph in the main screen.
5. Use Zoom to enlarge the graph, and then move it to the sub-screen.

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Example **Draw the graph $y = x(x + 1)(x - 1)$ in the main screen, and then use Box Zoom to enlarge it.**

Use the following V-Window settings.

(Main Screen)

Xmin = –2, Xmax = 2, Xscale = 0.5

Ymin = –2, Ymax = 2, Yscale = 1

Procedure

① [MENU] GRPH•TBL

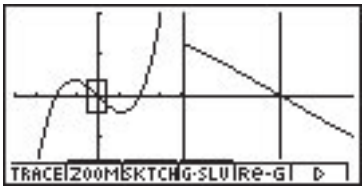
② [CTRL] [F3](SET UP) ▼ ▼ ▼ [F2](G+G) [ESC]

③ [SHIFT] [OPTN](V-Window) [(–)] [2] [EXE] [2] [EXE] [0] [•] [5] [EXE] ▼
[(–)] [2] [EXE] [2] [EXE] [1] [EXE] [ESC]

④ [F3](TYPE) [1](Y=) [X,θ,T] [(] [X,θ,T] [+] [1] [)] [(] [X,θ,T] [–] [1] [)] [EXE]
[F5](DRAW)

⑤ [F2](ZOOM) [1](BOX)
▼~▼ ▶~▶ [EXE]
▲~▲ ◀~◀ [EXE]

Result Screen



5-6 Manual Graphing

■ Rectangular Coordinate Graph

Description

Inputting the Graph command in the RUN • MAT Mode enables drawing of rectangular coordinate graphs.

Set Up

1. From the Main Menu, enter the RUN • MAT Mode.
2. Make V-Window settings.

Execution

3. Input the commands for drawing the rectangular coordinate graph.
4. Input the function.

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Example **Graph $y = 2x^2 + 3x - 4$**

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 2

Ymin = –10, Ymax = 10, Yscale = 2

Procedure

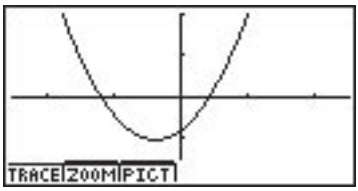
① MENU RUN • MAT

② SHIFT OPTN (V-Window) (↔) 5 EXE 5 EXE 2 EXE (▼)
(↔) 1 0 EXE 1 0 EXE 5 EXE ESC

③ OPTN F6 (▷) F6 (▷) F2 (SKTCH) 1 (Cls) EXE
F2 (SKTCH) 4 (GRAPH) 1 (Y=)

④ 2 X,θ,T x^2 + 3 X,θ,T − 4 EXE

Result Screen



■ Integration Graph

Description

Inputting the Graph command in the RUN • MAT Mode enables graphing of functions produced by an integration calculation.
The calculation result is shown in the lower left of the display, and the calculation range is blackened in the graph.

Set Up

1. From the Main Menu, enter the RUN • MAT Mode.
2. Make V-Window settings.

Execution

3. Input graph commands for the integration graph.
4. Input the function.

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Example **Draw the graph for the integral $y = \int_{-2}^{1}(x + 2)(x - 1)(x - 3)\,dx$, using 10 as the number of divisions.**

Use the following V-Window settings.

Xmin = –4, Xmax = 4, Xscale = 1

Ymin = –8, Ymax = 12, Yscale = 5

Procedure

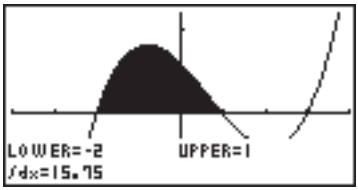
① MENU RUN • MAT

② SHIFT OPTN (V-Window) (↔) 4 EXE 4 EXE 1 EXE ▼
(↔) 8 EXE 1 2 EXE 5 EXE ESC

③ OPTN F6 (▷) F6 (▷) F2 (SKTCH) 1 (Cls) EXE
F2 (SKTCH) 4 (GRAPH) 2 ($\int dx$)

④ (X,θ,T + 2) (X,θ,T − 1) (X,θ,T − 3) ,
(↔) 2 , 1 , 1 0 EXE

Result Screen



■ Drawing Multiple Graphs on the Same Screen

Description

Use the following procedure to assign various values to a variable contained in an expression and overwrite the resulting graphs on the screen.

Set Up

1. From the Main Menu, Enter GRPH • TBL Mode.
2. Make V-Window settings.

Execution

3. Specify the function type and input the function. The following is the syntax for function input.

   Expression containing one variable [,] [SHIFT] [+] ([ ) variable [SHIFT] [•] (=)

   value [,] value [,] ... [,] value [SHIFT] [−] ( ])
4. Draw the graph.

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Example **To graph $y = Ax^2 - 3$ as the value of A changes in the sequence 3, 1, –1.**

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –10, Ymax = 10, Yscale = 2

Procedure

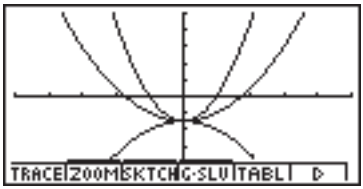
① MENU GRPH • TBL

② SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 1 EXE ▼
(–) 1 0 EXE 1 0 EXE 2 EXE ESC

③ F3 (TYPE) 1 (Y=) ALPHA X,θ,T (A) X,θ,T x^2 − 3 ,
SHIFT + ([ ) ALPHA X,θ,T (A) SHIFT • (=) 3 , 1 , (–) 1 SHIFT − ( ]) EXE

④ F5 (DRAW)

Result Screen



The value of only one of the variables in the expression can change.
Any of the following cannot be used for the variable name: X, Y, r, θ, T.
You cannot assign a variable to the variable inside the function.
When Simul Graph is turned on, all of the graphs for the specified variable values are drawn simultaneously.
Overwrite can be used when graphing rectangular expressions, polar expressions, parametric functions, X = constant functions and inequalities.

5-7 Using Tables

■ Storing a Function and Generating a Number Table

• To store a function

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Example **To store the function $y = 3x^2 - 2$ in memory area Y1**

Use ▲ and ▼ to move the highlighting in the Graph function list to the memory area where you want to store the function. Next, input the function and press [EXE] to store it.

• Variable Specifications

There are two methods you can use to specify value for the variable x when generating a numeric table.

• Table range method

With this method, you specify the conditions for the change in value of the variable.

• List

With this method, the data in the list you specify is substituted for the x-variable to generate a number table.

• To generate a table using a table range

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Example **To generate a table as the value of variable x changes from –3 to 3, in increments of 1**

[F6] (▷) [F2] (RANG)
(↩) [3] [EXE] [3] [EXE] [1] [EXE]

The numeric table range defines the conditions under which the value of variable x changes during function calculation.

Start ..... Variable x start value

End ..... Variable x end value

pitch ..... Variable x value change (interval)

After specifying the table range, press [ESC] to return to the Graph function list.

• To generate a table using a list

1. While the Graph function list is on the screen, display the SET UP screen.
2. Highlight Variable and then press [F2](LIST) to display the pop-up window.
3. Select the list whose values you want to assign for the x-variable.
   • To select List 6, for example, press [6] [EXE]. This causes the setting of the Variable item of the SET UP screen to change to List 6.
4. After specifying the list you want to use, press [ESC] to return to the previous screen.

• Note that the {RANG} item does not appear when a list name is specified for the Variable item of the SET UP screen.

• Generating a Table

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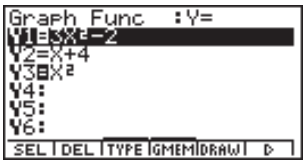
Example **To generate a table of values for the functions stored in memory areas Y1 and Y3 of the Graph function list**

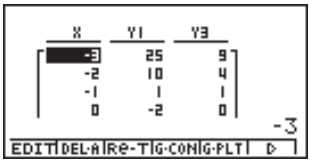
Use ▲ and ▼ to move the highlighting to the function you want to select for table generation and press [F1](SEL) to select it.

The "=" sign of selected functions is highlighted on the screen. To deselect a function, move the cursor to it and press [F1](SEL) again.



Press [F5](TABL) to generate a number table using the functions you selected. The value of variable x changes according to the range or the contents of the list you specified.

The example screen shown here shows the results based on the contents of List 6 (– 3, –2, –1, 0, 1, 2, 3).



Each cell can contain up to six digits, including negative sign.

You can use cursor keys to move the highlighting around the table for the following purposes.

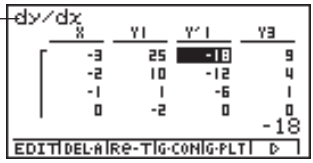
- To display the selected cell's value at the bottom of the screen, using the calculator's current number of decimal place, number of significant digit, and exponential display range settings
- To scroll the display and view parts of the table that do not fit in the display
- To display at the top of the screen the scientific function that produced the value in the selected cell (in columns Y1, Y2, etc.)
- To change x variable values by replacing values in column X

Press [ESC] to return to the Graph function list.

• To generate a differential number table *1

Changing the setting of SET UP screen's Derivative item to On causes a number table that includes the derivative to be displayed whenever you generate a number table.

Locating the cursor at a differential coefficient displays "dy/dx" in the top line, which indicates differential.



• Specifying the function type

You can specify a function as being one of three types.*2

- Rectangular coordinate (Y=)
- Polar coordinate (r =)
- Parametric (Param)

1. Press [F3] (TYPE) while the function list is on the screen.
2. Press the number key that corresponds to the function type you want to specify.

*1 An error occurs if a graph for which a range is specified or an overwrite graph is included among the graph expressions.

*2 The number table is generated only for the function type specified on the function list (Graph Func). You cannot generate a number table for a mixture of different function types.

■ Editing and Deleting Functions

• To edit a function

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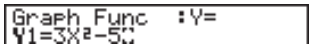
Example **To change the function in memory area Y1 from $y = 3x^2 - 2$ to $y = 3x^2 - 5$**

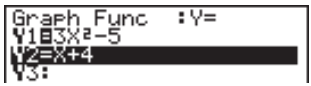
Use ▲ and ▼ to move the highlighting to the function you want to edit.

Use ◀ and ▶ to move the cursor to the location of the change.

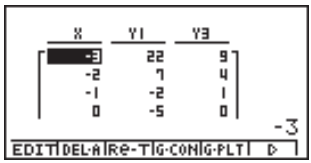
▶▶▶▶▶ DEL 5



EXE



F6 (▷) F5 (TABL)



- The Function Link Feature automatically reflects any changes you make to functions in the GRPH • TBL Mode list, and DYNA Mode list.

• To delete a function

1. Use ▲ and ▼ to move the highlighting to the function you want to delete and then press F2 (DEL) or DEL.
2. Press EXE (Yes) to delete the function or ESC (No) to abort the operation without deleting anything.

■ Editing Tables

You can use the table menu to perform any of the following operations once you generate a table.

- Change the values of variable x
- Edit (delete, insert, and append) rows
- Delete a table and regenerate table
- Draw a connect type graph
- Draw a plot type graph

While the Table & Graph menu is on the display, press F3 (TABL) to display the table menu.

- {**EDIT**} ... {edit value of x-variable}
- {**DEL·A**} ... {delete table}
- {**Re-T**} ... {regenerate table from function}
- {**G·CON**}/{**G·PLT**} ... {connected type}/{draw plot type} graph draw
- {**R·DEL**}/{**R·INS**}/{**R·ADD**} ... {delete}/{insert}/{add} row

• To change variable values in a table

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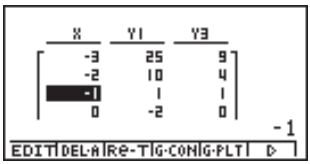
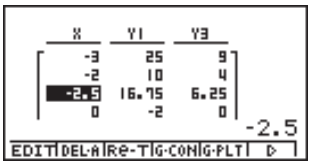
Example **To change the value in Column x, Row 3 of the table generated on page 5-7-2 from – 1 to – 2.5**

(▼)(▼)



(⟵) 2 • 5 EXE



- When you change a variable value in Column x, all values in the columns to the right are recalculated and displayed.

If you try to replace a value with an illegal operation (such as division by zero), an error occurs and the original value remains unchanged.

You cannot directly change any values in the other (non-x) columns of the table.

• Row Operations

• To delete a row

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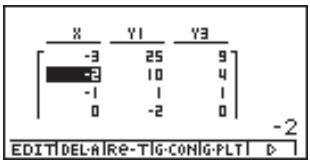
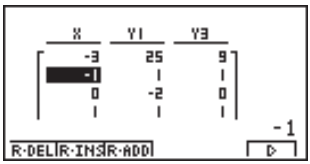
Example **To delete Row 2 of the table generated on page 5-7-2**

(▼)



F6(▷)F1(R·DEL)



• To insert a row

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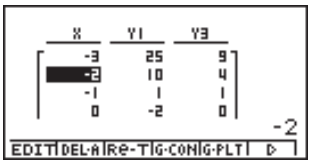
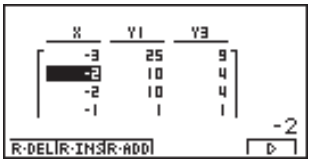
Example **To insert a new row between Rows 1 and 2 in the table generated on page 5-7-2**

(▼)



F6(▷)F2(R·INS)



• To add a row

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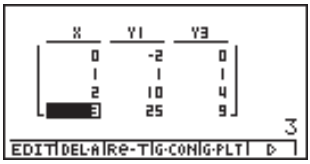
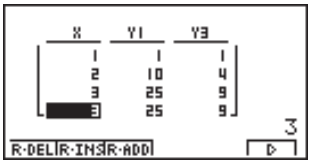
Example **To add a new row below Row 7 in the table generated on page 5-7-2**

(▼)(▼)(▼)(▼)(▼)(▼)



F6(▷)F3(R·ADD)



• Deleting a Table

1. Display the table and then press F2(DEL·A).
2. Press EXE(Yes) to delete the table or ESC(No) to abort the operation without deleting anything.

■ Copying a Table Column to a List

A simple operation lets you copy the contents of a numeric table column into a list.

• To copy a table to a list

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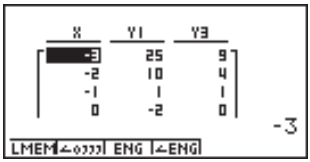
Example **To copy the contents of Column x into List 1**

[OPTN] [F1] (LMEM)

• You can select any row of the column you want to copy.

Input the number of the list you want to copy and then press [EXE].

[1] [EXE]



■ Drawing a Graph from a Number Table

Description

Use the following procedure to generate a number table and then draw a graph based on the values in the table.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Make V-Window settings.

Execution

3. Store the functions.
4. Specify the table range.
5. Generate the table.
6. Select the graph type and draw it.
   F4 (G • CON) ... line graph*1
   F5 (G • PLT) ... plot type graph*1*2

*1 After drawing the graph, pressing CTRL F5 (G ↔ T) or ESC returns to the function storage screen. To return to the number table screen, press F5 (TABL).

*2 Pressing F6 (▷) F4 (G • PLT) on the function storage screen generates the number table and plots the graph simultaneously.

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Example **Store the two functions below, generate a number table, and then draw a line graph. Specify a range of –3 to 3, and a increment of 1.**
Y1 = $3x^2 - 2$, Y2 = x^2

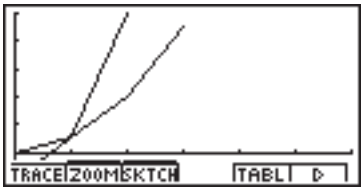
Use the following V-Window settings.

Xmin = 0, Xmax = 6, Xscale = 1
Ymin = –2, Ymax = 10, Yscale = 2

Procedure

① MENU GRPH • TBL
② SHIFT OPTN (V-Window) 0 EXE 6 EXE 1 EXE ▼
(–) 2 EXE 1 0 EXE 2 EXE ESC
③ F3 (TYPE) 1 (Y=) 3 X,θ,T x^2 − 2 EXE
X,θ,T x^2 EXE
④ F6 (▷) F2 (RANG) (–) 3 EXE 3 EXE 1 EXE ESC
⑤ F5 (TABL)
⑥ F4 (G • CON)

Result Screen



You can use Trace, Zoom, or Sketch after drawing a graph.

■ Specifying a Range for Number Table Generation

Description

Use the following procedure to specify a number table range when calculating scatter data from a function.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.

Execution

2. Store the functions.
3. Specify the table range.
4. Select the functions for which you want to generate a table.
   The “=” sign of selected functions is highlighted on the screen.
5. Generate the table.

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Example **Store the three functions shown below, and then generate a table for functions Y1 and Y3. Specify a range of –3 to 3, and a increment of 1.**

Y1 = $3x^2 - 2$, Y2 = $x + 4$, Y3 = x^2

Procedure

① MENU GRPH • TBL

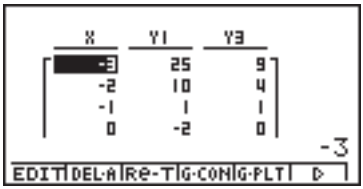
② F3(TYPE) 1(Y=) 3 X,θ,T x^2 − 2 EXE
X,θ,T + 4 EXE
X,θ,T x^2 EXE

③ F6(▷) F2(RANG) (↔) 3 EXE 3 EXE 1 EXE ESC

④ ▲ ▲ F1(SEL)

⑤ F5(TABL)

Result Screen



You can generate number tables from rectangular coordinate, polar coordinate, and parametric functions.

You can include derivatives in generated number tables by specifying On for the Derivative item on the SET UP screen.

■ Simultaneously Displaying a Number Table and Graph

Description

Specifying T+G for Dual Screen on the SET UP makes it possible to display a number table and graph at the same time.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Make V-Window settings.
3. On the SET UP screen, select T+G for Dual Screen.

Execution

4. Input the function.
5. Specify the table range.
6. The number table is displayed in the sub-screen on the right.
7. Specify the graph type and draw the graph.
   F4(G • CON) ... line graph
   F5(G • PLT) ... plot type graph*1

*1 Pressing F6(▷) F4(G • PLT) on the function storage screen generates the number table and plots the graph simultaneously.

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Example **Store the function Y1 = $3x^2$ – 2 and simultaneously display its number table and line graph. Use a table range of –3 to 3 with a increment of 1.**

Use the following V-Window settings.

Xmin = 0, Xmax = 6, Xscale = 1

Ymin = –2, Ymax = 10, Yscale = 2

Procedure

① MENU GRPH•TBL

② SHIFT OPTN (V-Window) 0 EXE 6 EXE 1 EXE ▼
(−) 2 EXE 1 0 EXE 2 EXE ESC

③ CTRL F3 (SET UP) ▼ ▼ ▼ F1 (T+G) ESC

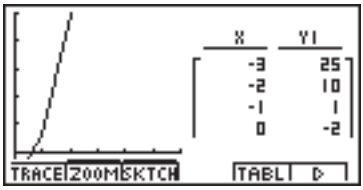
④ F3 (TYPE) 1 (Y=) 3 X,θ,T x^2 − 2 EXE

⑤ F6 (▷) F2 (RANG)
(−) 3 EXE 3 EXE 1 EXE ESC

⑥ F5 (TABL)

⑦ F4 (G•CON)

Result Screen



■ Using Graph-Table Linking

Description

With Dual Graph, you can use the following procedure to link the graph and table screens so the pointer on the graph screen jumps to the location of the currently selected table value.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Make the required V-Window settings.

   Display the SET UP screen, select the Dual Screen item, and change its setting to "T+G".

Execution

3. Input the function of the graph and make the required table range settings.
4. With the number table on the right side of the display, draw the graph on the left side.

   F4 (G • CON) ... connect type graph

   F5 (G • PLT) ... plot type graph
5. Turn on G • Link.
6. Now when you use ▼ and ▲ to move the highlighting among the cells in the table, the pointer jumps to the corresponding point on the graph screen.
   If there are multiple graphs, pressing ◀ and ▶ causes the pointer to jump between them.

To turn off G • Link, press ESC or SHIFT ESC (QUIT).

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Example **Store the function Y1 = 3log$x$ and simultaneously display its number table and plot-type graph. Use a table range of 2 through 9, with an increment of 1.**

Use the following V-Window settings.

Xmin = –1, Xmax = 10, Xscale = 1
Ymin = –1, Ymax = 4, Yscale = 1

Procedure

① MENU GRPH • TBL

② SHIFT OPTN (V-Window) (↔) 1 EXE 1 0 EXE 1 EXE ▼
(↔) 1 EXE 4 EXE 1 EXE ESC
CTRL F3 (SET UP) ▼ ▼ ▼ F1 (T+G) ESC

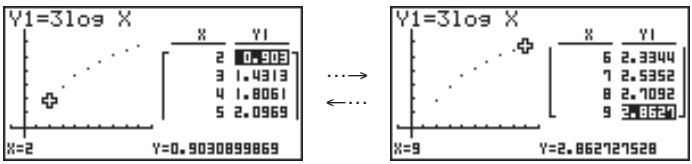
③ F3 (TYPE) 1 (Y=) 3 log X,θ,T EXE
F6 (▷) F2 (RANG)
2 EXE 9 EXE 1 EXE ESC

④ F5 (TABL)
F5 (G • PLT)

⑤ F6 (▷) F4 (G • Link)

⑥ ▼ ~ ▼, ▲ ~ ▲

Result Screen



5-8 Dynamic Graphing

■ Using Dynamic Graph

Description

Dynamic Graph lets you define a range of values for the coefficients in a function, and then observe how a graph is affected by changes in the value of a coefficient. It helps to see how the coefficients and terms that make up a function influence the shape and position of a graph.

Set Up

1. From the Main Menu, enter the DYNA Mode.
2. Make V-Window settings.

Execution

3. On the SET UP screen, specify the Dynamic Type.
   F1(Cont) ... Continuous
   F2(Stop) ... Automatic stop after 10 draws
4. Use the cursor keys to select the function type on the built-in function type list.*1
5. Input values for coefficients, and specify which coefficient will be the dynamic variable.*2
6. Specify the start value, end value, and increment.
7. Specify the drawing speed.
   F3(SPEED) F1(⏸▷) .....Pause after each draw (Stop & Go)
   F2(▷) .....Half normal speed (Slow)
   F3(▶) .....Normal speed (Normal)
   F4(▶▶) .....Twice normal speed (Fast)
8. Draw the Dynamic Graph.

*1 The following are the seven built-in function types.
- Y=AX+B
- Y=A(X–B)²+C
- Y=AX²+BX+C
- Y=AX^3+BX²+CX+D
- Y=Asin(BX+C)
- Y=Acos(BX+C)
- Y=Atan(BX+C)

After you press F3(TYPE) and select the function type you want, you can then input the actual function.

1 ... rectangular coordinate expression
2 ... polar coordinate expression
3 ... parametric function

*2 You could also press EXE here and display the parameter setting menu.

The message “Too Many Functions” appears when more than one function is selected for Dynamic Graphing.

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Example **Use Dynamic Graph to graph $y = A(x - 1)^2 - 1$, in which the value of coefficient A changes from 2 through 5 in increments of 1. The Graph is drawn 10 times.**

Use the following V-Window settings.

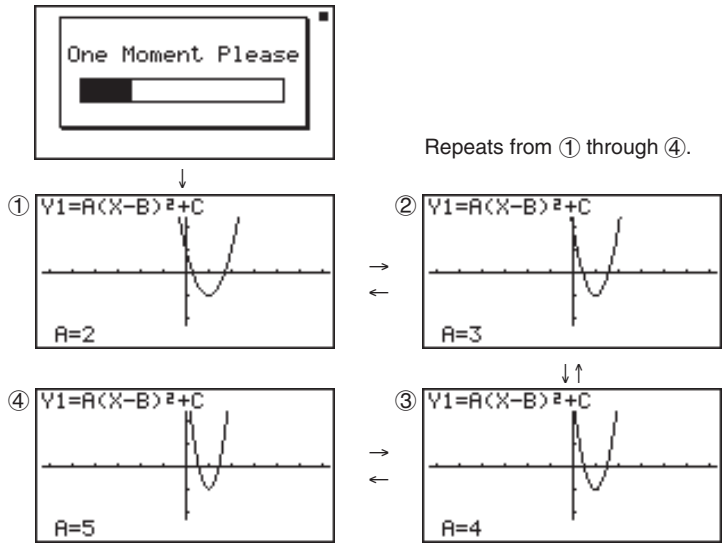
Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1 (initial defaults)

Procedure

① MENU DYNA
② SHIFT OPTN (V-Window) F1 (INIT) ESC
③ CTRL F3 (SET UP) F2 (Stop) ESC
④ F6 (▷) F3 (B-IN) ▼ F1 (SEL)
⑤ F6 (▷) F4 (VAR) 2 EXE 1 EXE (–) 1 EXE
⑥ F2 (RANG) 2 EXE 5 EXE 1 EXE ESC
⑦ F3 (SPEED) F3 (▶) ESC
⑧ F6 (DYNA)

Result Screen



■ Dynamic Graph Application Examples

Description

You can also use Dynamic Graph to simulate simple physical phenomena.

Set Up

1. From the Main Menu, enter the DYNA Mode.
2. Make V-Window settings.

Execution

3. On the SET UP screen, specify Stop for Dynamic Type and Deg for Angle.
4. Specify Param (parametric function) as the function type, and input a function that contains a dynamic variable.
5. Specify the dynamic coefficient.
6. Specify the start value, end value, and increment.
7. Specify Normal for the draw speed.
8. Start the Dynamic Graph operation.

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Example **The path over time T off a ball thrown in the air at initial velocity V and an angle of θ degrees from horizontal can be calculated as follows. $X = (V\cos\theta)T$, $Y = (V\sin\theta)T - (1/2)gT^2$ ($g = 9.8 m/s^2$)**

Use Dynamic Graph to plot the path of a ball thrown at an initial velocity of 20 meters per second, at horizontal angles of 30, 45, and 60 degrees (Angle: Deg).

Use the following V-Window settings.

Xmin = –1, Xmax = 42, Xscale = 5

Ymin = –1, Ymax = 16, Yscale = 2

Procedure

① MENU DYNA

② SHIFT OPTN (V-Window) (↔) 1 EXE 4 2 EXE 5 EXE ▼
(↔) 1 EXE 1 6 EXE 2 EXE ESC

③ CTRL F3 (SET UP) F2 (Stop)
▼ ▼ ▼ ▼ F1 (Deg) ESC

④ F3 (TYPE) 3 (Param)
(2 0 cos ALPHA X,θ,T (A)) X,θ,T EXE
(2 0 sin ALPHA X,θ,T (A)) X,θ,T − 4 • 9 X,θ,T x^2 EXE

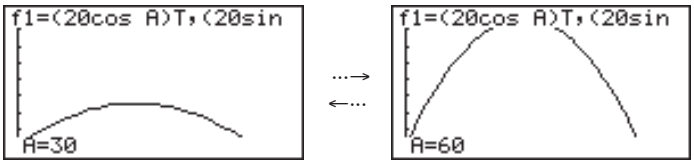
⑤ F4 (VAR)

⑥ F2 (RANG) 3 0 EXE 6 0 EXE 1 5 EXE ESC

⑦ F3 (SPEED) F3 (▶) ESC

⑧ F6 (DYNA)

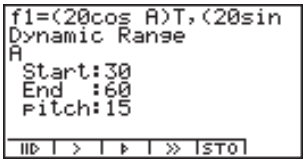
Result Screen



■ Adjusting the Dynamic Graph Speed

You can use the following procedure to adjust the Dynamic Graph speed while the draw operation is taking place.

1. While a Dynamic Graph draw operation is being performed, press [AC] to change to the speed adjustment menu.



   - {⏸▷} ... {Each step of the Dynamic Graph draw operation is performed each time you press [EXE].}
   - {>}/{▷}/{»} ... {slow (1/2 speed)}/{normal (default speed)}/{fast (double speed)}
   - {**STO**} ... {stores graph conditions and screen data in Dynamic Graph memory}

2. Press the function key ([F1] to [F4]) that corresponds to the speed you want to change to.

To clear the speed adjustment menu without changing anything, press [EXE].

Press [CTRL] [F5] (G↔T) to return to the graph screen.

■ Using Dynamic Graph Memory

You can store Dynamic Graph conditions and screen data in Dynamic Graph memory for later recall when you need it. This lets you save time, because you can recall the data and immediately begin a Dynamic Graph draw operation. Note that you can store one set of data in memory at any one time.

The following is all of the data that makes up a set.

- Graph functions (up to 20)
- Dynamic Graph conditions
- SET UP screen settings
- V-Window contents
- Dynamic Graph screen

● To save data in Dynamic Graph memory

1. While a Dynamic Graph draw operation is being performed, press [AC] to change to the speed adjustment menu.
2. Press [F5] (STO). In response to the confirmation dialog that appears, press [EXE] (Yes) to save the data.

● To recall data from Dynamic Graph memory

1. Display the Dynamic Graph function list.
2. Press [F6] (RCL) to recall all the data stored in Dynamic Graph memory.

If there is already data stored in Dynamic Graph memory, the data save operation replaces it with the new data.

Data recalled from Dynamic Graph memory replaces the calculator's current graph functions, draw conditions, and screen data. The previous data is lost when it is replaced.

5-9 Graphing a Recursion Formula

■ Generating a Number Table from a Recursion Formula

Description

You can input up to three of the following types of recursion formulas and generate a number table.

- General term of sequence $\{a_n\}$, composed of a_n, n
- Linear two-term recursion composed of a_{n+1}, a_n, n
- Linear three-term recursion composed of a_{n+2}, a_{n+1}, a_n, n

Set Up

1. From the Main Menu, enter the RECUR Mode.

Execution

2. Specify the recursion type.
   F3(TYPE) 1(a_n=) ... {general term of sequence a_n}
   2(a_{n+1}=) ... {linear two-term recursion}
   3(a_{n+2}=) ... {linear three-term recursion}
3. Input the recursion formula.
4. Specify the table range. Specify a start point and end point for n. If necessary, specify a value for the initial term, and a pointer start point value if you plan to graph the formula.
5. Display the recursion formula number table.

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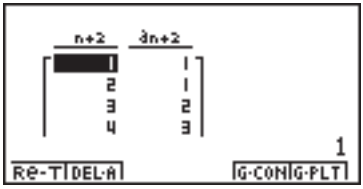
Example **Generate a number table from recursion between three terms as expressed by $a_{n+2} = a_{n+1} + a_n$, with initial terms of $a_1 = 1$, $a_2 = 1$ (Fibonacci sequence), as n changes in value from 1 to 6.**

Procedure

① MENU RECUR
② F3(TYPE) 3 (a_{n+2}=)
③ F4(n. a_n ··) 3 (a_{n+1}) + F2 (a_n) EXE
④ F5(RANG) F2(a_1) 1 EXE 6 EXE 1 EXE 1 EXE ESC
⑤ F6(TABL)

Result Screen



Specifying On for the Σ Display of the SET UP screen causes the sum of each term to be included in the table.

■ Graphing a Recursion Formula (1)

Description

After generating a number table from a recursion formula, you can graph the values on a line graph or plot type graph.

Set Up

1. From the Main Menu, enter the RECUR Mode.
2. Make V-Window settings.

Execution

3. Specify the recursion formula type and input the formula.
4. Specify the table range, and start and ending values for n. If necessary, specify the initial term value and pointer start point.
5. Display the recursion formula number table.
6. Specify the graph type and draw the graph.
   F5(G • CON) ... line graph
   F6(G • PLT) ... plot type graph

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Example **Generate a number table from recursion between two terms as expressed by $a_{n+1} = 2a_n+1$, with an initial term of $a_1 = 1$, as n changes in value from 1 to 6. Use the table values to draw a line graph.**

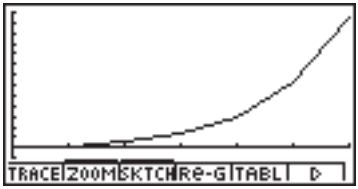
Use the following V-Window settings.

Xmin = 0, Xmax = 6, Xscale = 1
Ymin = –15, Ymax = 65, Yscale = 5

Procedure

① MENU RECUR
② SHIFT OPTN (V-Window) 0 EXE 6 EXE 1 EXE ▼
(–) 1 5 EXE 6 5 EXE 5 EXE ESC
③ F3 (TYPE) 2 (a_{n+1}=) 2 F2 (a_n) + 1 EXE
④ F5 (RANG) F2 (a_1) 1 EXE 6 EXE 1 EXE ESC
⑤ F6 (TABL)
⑥ F5 (G•CON)

Result Screen



■ Graphing a Recursion Formula (2)

Description

The following describes how to generate a number table from a recursion formula and graph the values while Σ Display is On.

Set Up

1. From the Main Menu, enter the RECUR Mode.
2. On the SET UP screen, specify On for Σ Display.
3. Make V-Window settings.

Execution

4. Specify the recursion formula type and input the recursion formula.
5. Specify the table range, and start and ending values for n. If necessary, specify the initial term value and pointer start point.
6. Display the recursion formula number table.
7. Specify the graph type and draw the graph.

   F5(G • CON) 1(a_n) ... Line graph with ordinate a_n, abscissa n

   2(Σa_n) ... Line graph with ordinate Σa_n, abscissa n

   F6(G • PLT) 1(a_n) ... Plot type graph with ordinate a_n, abscissa n

   2(Σa_n) ... Plot type graph with ordinate Σa_n, abscissa n

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Example **Generate a number table from recursion between two terms as expressed by $a_{n+1} = 2a_n+1$, with an initial term of $a_1 = 1$, as n changes in value from 1 to 6. Use the table values to draw a plot line graph with ordinate Σa_n, abscissa n.**

Use the following V-Window settings.

Xmin = 0, Xmax = 6, Xscale = 1

Ymin = −15, Ymax = 65, Yscale = 5

Procedure

① MENU RECUR

② CTRL F3(SET UP) F1(On) ESC

③ SHIFT OPTN(V-Window) 0 EXE 6 EXE 1 EXE ▼
(−) 1 5 EXE 6 5 EXE 5 EXE ESC

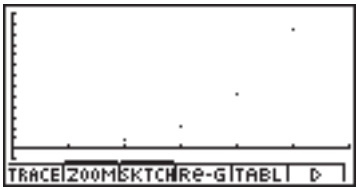
④ F3(TYPE) 2 (a_{n+1}=) 2 F2(a_n) + 1 EXE

⑤ F5(RANG) F2(a_1) 1 EXE 6 EXE 1 EXE ESC

⑥ F6(TABL)

⑦ F6(G • PLT) 2 (Σa_n)

Result Screen



■ WEB Graph (Convergence, Divergence)

Description

$y = f(x)$ is graphed by presuming $a_{n+1} = y$, $a_n = x$ for linear two-term regression $a_{n+1} = f(a_n)$ composed of a_{n+1}, a_n. Next, it can be determined whether the function is convergent or divergent.

Set Up

1. From the Main Menu, enter the RECUR Mode.
2. Make V-Window settings.

Execution

3. Select 2-term recursion as the recursion formula type, and input the formula.
4. Specify the table range, n start and end points, initial term value, and pointer start point.
5. Display the recursion formula number table.
6. Draw the graph.
7. Press [EXE], and the pointer appears at the start point you specified.
   Press [EXE] several times.

   If convergence exists, lines that resemble a spider web are drawn on the display. Failure of the web lines to appear indicates either divergence or that the graph is outside the boundaries of the display screen. When this happens, change to larger View Window values and try again.

   You can use ▲ ▼ to select the graph.

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Example **To draw the WEB graph for the recursion formula $a_{n+1} = -3(a_n)^2 + 3a_n$, $b_{n+1} = 3b_n + 0.2$, and check for divergence or convergence. Use the following table range and V-Window Settings.**

Table Range

Start = 0, End = 6, $a_0 = 0.01$, a_nStr = 0.01, $b_0 = 0.11$, b_nStr = 0.11

V-Window Settings

Xmin = 0, Xmax = 1, Xscale = 1

Ymin = 0, Ymax = 1, Yscale = 1

Procedure

① [MENU] RECUR

② [SHIFT] [OPTN] (V-Window) [0] [EXE] [1] [EXE] [1] [EXE] [▼]
[0] [EXE] [1] [EXE] [1] [EXE] [ESC]

③ [F3] (TYPE) [2] (a_{n+1}=) [(–)] [3] [F2] (a_n) [x^2] [+] [3] [F2] (a_n) [EXE]
[3] [F3] (b_n) [+] [0] [·] [2] [EXE]

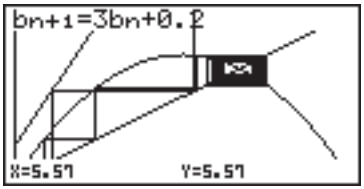
④ [F5] (RANG) [F1] (a_0)
[0] [EXE] [6] [EXE] [0] [·] [0] [1] [EXE] [0] [·] [1] [1] [EXE] [▼]
[0] [·] [0] [1] [EXE] [0] [·] [1] [1] [EXE] [ESC]

⑤ [F6] (TABL)

⑥ [F4] (WEB)

⑦ [F1] (TRACE) [EXE] ~ [EXE] (a_n is convergence)
[▼] [EXE] ~ [EXE] (b_n is divergence)

Result Screen



5-10 Changing the Appearance of a Graph

■ Drawing a Line

Description

The sketch function lets you draw points and lines inside of graphs.

Set Up

1. Draw the graph.

Execution

2. Select the sketch function you want to use.*1

   F3 (SKTCH) 1 (Cls) ... Screen clear

   2 (PLOT)
   {On}/{Off}/{Change}/{Plot} ... Point {On}/{Off}/{Change}/{Plot}

   3 (LINE)
   {F-Line}/{Line} ... {Freehand line}/{Line}

   4 (Text) ... Text input

   5 (Pen) ... Freehand

   6 (Tangnt) ... Tangent line

   7 (Normal) ... Line normal to a curve

   8 (Invrse) ... Inverse function*2

   9 (Circle) ... Circle

   X,θ,T (Vert) ... Vertical line

   log (Horz) ... Horizontal line

3. Use the cursor keys to move the pointer (✜) to the location where you want to draw, and press EXE.*3

*1 The above shows the function menu that appears in the GRPH•TBL Mode. Menu items may differ somewhat in other modes.

*2 In the case of an inverse function graph, drawing starts immediately after you select this option.

*3 Some sketch functions require specification of two points. After you press EXE to specify the first point, use the cursor keys to move the pointer to the location of the second point and press EXE.

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Example **Draw a line that is tangent to point (2, 0) on the graph for $y = x(x + 2)(x - 2)$.**

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –5, Ymax = 5, Yscale = 1

Procedure

① MENU GRPH•TBL

SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 1 EXE ▼

(–) 5 EXE 5 EXE 1 EXE ESC

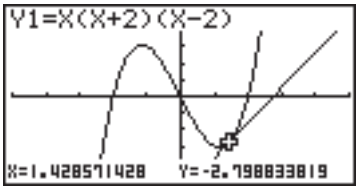
F3 (TYPE) 1 (Y=) X,θ,T (X,θ,T + 2) (X,θ,T − 2) EXE

F5 (DRAW)

② F3 (SKTCH) 6 (Tangnt)

③ ▶~▶ EXE *1

Result Screen



*1 You can draw a tangent line in succession by moving the "✛" pointer and pressing EXE.

■ Inserting Comments

Description

You can insert comments anywhere you want in a graph.

Set Up

1. Draw the graph.

Execution

2. Press F3 (SKTCH) 4 (Text), and a pointer appears in the center of the display.
3. Use the cursor keys to move the pointer to the location where you want the text to be, and input the text.

You can input any of the following characters as comment text: A~Z, r, θ, space, 0~9, ., +, –, ×, ÷, (–), EXP, π, Ans, (,), [,], {, }, comma, →, x^2, ^, log, ln, $\sqrt{\ }$, $\sqrt[x]{\ }$, 10^x, e^x, $\sqrt[3]{\ }$, x^{-1}, sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, i, List, Mat

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Example **Insert text into the graph $y = x\ (x + 2)(x - 2)$.**

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –5, Ymax = 5, Yscale = 1

Procedure

① MENU GRPH•TBL

SHIFT OPTN (V-Window) (↔) 5 EXE 5 EXE 1 EXE (▼)

(↔) 5 EXE 5 EXE 1 EXE ESC

F3 (TYPE) 1 (Y=) X,θ,T (X,θ,T + 2) (X,θ,T − 2) EXE

F5 (DRAW)

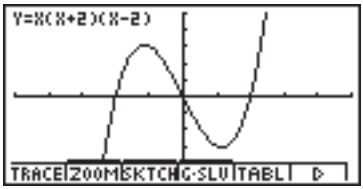
② F3 (SKTCH) 4 (Text)

③ (▲)(▼)(▶)(▶)

ALPHA − (Y) SHIFT • (=) X,θ,T (X,θ,T + 2) (X,θ,T − 2)

ESC

Result Screen



■ Freehand Drawing

Description

You can use the pen option for freehand drawing in a graph.

Set Up

1. Draw the graph.

Execution

2. Press [F3] (SKTCH) [5] (Pen), and a pointer appears in the center of the screen.
3. Use the cursor keys to move the pointer to the point from which you want to start drawing, and then press [EXE].
4. Use the cursor keys to move the pointer. A line is drawn wherever you move the pointer. To stop the line, press [EXE].

   Repeat step 3 and 4 to draw other lines.

   After you are finished drawing, press [ESC].

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Example **Use the pen to draw on the graph $y = x\ (x + 2)(x - 2)$.**

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –5, Ymax = 5, Yscale = 1

Procedure

① MENU GRPH•TBL

SHIFT OPTN (V-Window) (↔) 5 EXE 5 EXE 1 EXE (▼)

(↔) 5 EXE 5 EXE 1 EXE ESC

F3 (TYPE) 1 (Y=) X,θ,T (X,θ,T + 2) (X,θ,T − 2) EXE

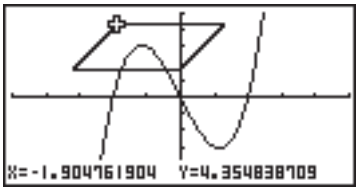
F5 (DRAW)

② F3 (SKTCH) 5 (Pen)

③ (▲)(▼)(▶)(▶) EXE

④ (▲)(▼)(▶)(▶) EXE

Result Screen



■ Changing the Graph Background

You can use the set up screen to specify the memory contents of any picture memory area (Pict 1 through Pict 20) as the Background item. When you do, the contents of the corresponding memory area is used as the background of the graph screen.

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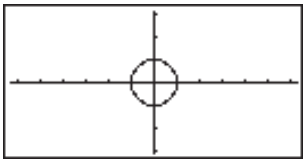
Example 1 **With the circle graph $X^2 + Y^2 = 1$ as the background, use Dynamic Graph to graph $Y = X^2 + A$ as variable A changes value from –1 to 1 in increments of 1.**

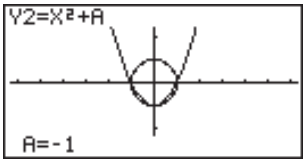
Recall the background graph.

($X^2 + Y^2 = 1$)



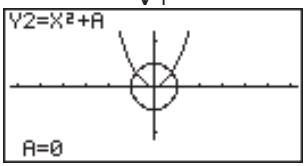
Draw the dynamic graph.

($Y = X^2 - 1$)



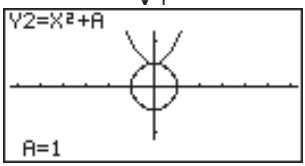
↓↑

($Y = X^2$)



↓↑

($Y = X^2 + 1$)



• See “5-8-1 Dynamic Graphing” for details on using the Dynamic Graph feature.

5-11 Function Analysis

■ Reading Coordinates on a Graph Line

Description

Trace lets you move a pointer along a graph and read out coordinates on the display.

Set Up

1. Draw the graph.

Execution

2. Press F1 (TRACE), and a pointer appears in the center of the graph.*1
3. Use ◀ and ▶ to move the pointer along the graph to the point at which you want to display the derivative.

   When there are multiple graphs on the display, press ▲ and ▼ to move between them along the x-axis of the current pointer location.
4. You can also move the pointer by pressing X,θ,T to display the pop up window, and then inputting coordinates.

To exit a trace operation, press ESC.

*1 The pointer is not visible on the graph when it is located at point outside the graph display area or when an error no value occurs.

You can turn off display of the coordinates at the pointer location by specifying “Off” for the “Coord” item on the SET UP screen.

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Example **Read coordinates along the graph of the function shown below.**
Y1 = x^2 – 3

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –10, Ymax = 10, Yscale = 2

Procedure

① MENU GRPH•TBL

SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 1 EXE ▼

(–) 1 0 EXE 1 0 EXE 2 EXE ESC

F3 (TYPE) 1 (Y=) X,θ,T x^2 − 3 EXE

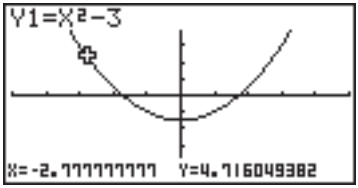
F5 (DRAW)

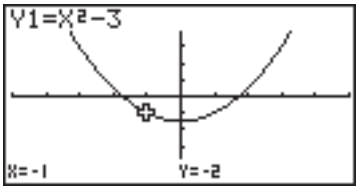
② F1 (TRACE)

③ ◀~◀

④ X,θ,T (–) 1 EXE

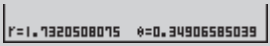
Result Screen



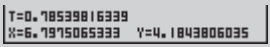


The following shows how coordinates are displayed for each function type.

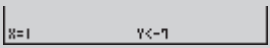
• **Polar Coordinate Graph**



• **Parametric Graph**



• **Inequality Graph**



■ Displaying the Derivative

Description

In addition to using Trace to display coordinates, you can also display the derivative at the current pointer location.

Set Up

1. On the SET UP screen, specify On for Derivative.
2. Draw the graph.

Execution

3. Press F1 (TRACE), and the pointer appears at the center of the graph. The current coordinates and the derivative also appear on the display at this time.
4. Use ◀ and ▶ to move the pointer along the graph to the point at which you want to display the derivative.

   When there are multiple graphs on the display, press ▲ and ▼ to move between them along the x-axis of the current pointer location.
5. You can also move the pointer by pressing X,θ,T to display the pop up window, and then inputting coordinates.

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Example **Read coordinates and derivatives along the graph of the function shown below.**

Y1 = $x^2 - 3$

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –10, Ymax = 10, Yscale = 2

Procedure

① MENU GRPH • TBL

CTRL F3 (SET UP) ▼ ▼ ▼ ▼ ▼ F1 (On) ESC

② SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 1 EXE ▼

(–) 1 0 EXE 1 0 EXE 2 EXE ESC

F3 (TYPE) 1 (Y=) X,θ,T x^2 − 3 EXE

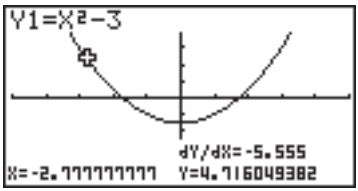
F5 (DRAW)

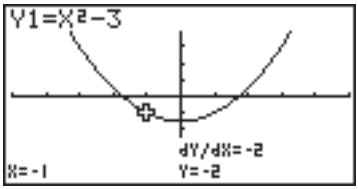
③ F1 (TRACE)

④ ◀~◀

⑤ X,θ,T (–) 1 EXE

Result Screen





■ Graph to Table

Description

You can use trace to read the coordinates of a graph and store them in a number table. You can also use Dual Graph to simultaneously store the graph and number table, making this an important graph analysis tool.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. On the SET UP screen, specify GtoT for Dual Screen.
3. Make V-Window settings.

Execution

4. Save the function and draw the graph on the active (left) screen.
5. Activate Trace. When there are multiple graphs on the display, press ▲ and ▼ to select the graph you want.
6. Use ◀ to move the pointer and press EXE to store coordinates into the number table. Repeat this step to store as many values as you want.
7. Press F6 (CHNG) to switch the number table side.
8. From the pop-up window, input the list number you want to save.

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Example **Save in a table the coordinates in the vicinity of the points of intersection at X = 0 for the two graphs shown below, and store the table contents in List 1.**

Y1 = x^2 – 3, Y2 = – x + 2

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –10, Ymax = 10, Yscale = 2

Procedure

① MENU GRPH•TBL

② CTRL F3(SET UP) ▼ ▼ ▼ F3(GtoT) ESC

③ SHIFT OPTN(V-Window) (–) 5 EXE 5 EXE 1 EXE ▼
(–) 1 0 EXE 1 0 EXE 2 EXE ESC

④ F3(TYPE) 1(Y=) X,θ,T x^2 − 3 EXE
(–) X,θ,T + 2 EXE
F5(DRAW)

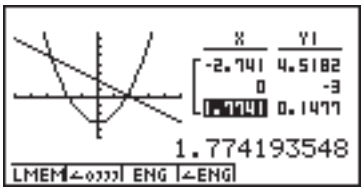
⑤ F1(TRACE)

⑥ ◀~◀ EXE ▶~▶ EXE ESC

⑦ F6(CHNG)

⑧ OPTN F1(LMEM) 1 EXE

Result Screen



■ Coordinate Rounding

Description

This function rounds off coordinate values displayed by Trace.

Set Up

1. Draw the graph.

Execution

2. Press [F2] (ZOOM) [8] (Rnd). This causes the V-Window settings to be changed automatically in accordance with the Rnd value.
3. Press [F1] (TRACE), and then use the cursor keys to move the pointer along the graph. The coordinates that now appear are rounded.

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Example **Use coordinate rounding and display the coordinates in the vicinity of the points of intersection for the two graphs produced by the functions shown below.**
Y1 = x^2 – 3, Y2 = – x + 2

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1
Ymin = –10, Ymax = 10, Yscale = 2

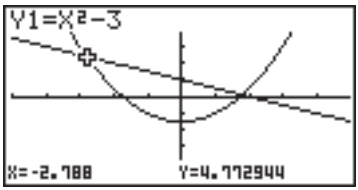
Procedure

① [MENU] GRPH • TBL
[SHIFT] [OPTN] (V-Window) [(–)] [5] [EXE] [5] [EXE] [1] [EXE] [▼]
[(–)] [1] [0] [EXE] [1] [0] [EXE] [2] [EXE] [ESC]
[F3] (TYPE) [1] (Y=) [X,θ,T] [x^2] [–] [3] [EXE]
[(–)] [X,θ,T] [+] [2] [EXE]
[F5] (DRAW)

② [F2] (ZOOM) [8] (Rnd)

③ [F1] (TRACE)
[◀] ~ [◀]

Result Screen



■ Calculating the Root

Description

This feature provides a number of different methods for analyzing graphs.

Set Up

1. Draw the graphs.

Execution

2. Select the analysis function.
   F4(G-SLV) 1(Root) ... Calculation of root
   2(Max) ... Maximum value
   3(Min) ... Minimum value
   4(Y-Icpt) ... y-intercept
   5(Isect) ... Intersection of two graphs
   6(Y-Cal) ... y-coordinate for given x-coordinate
   7(X-Cal) ... x-coordinate for given y-coordinate
   8($\int dx$) ... Integral value for a given range
3. When there are multiple graphs on the screen, the selection cursor (■) is located at the lowest numbered graph. Use the cursor keys to move the cursor to the graph you want to select.
4. Press EXE to select the graph where the cursor is located and display the value produced by the analysis.
   When an analysis produces multiple values, press ▶ to calculate the next value. Pressing ◀ returns to the previous value.

● ● ● ● ●

Example **Draw the graph shown below and calculate the root for Y1.**
Y1 = $x(x + 2)(x - 2)$

Use the following V-Window settings.

Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1 (initial defaults)

Procedure

① MENU GRPH • TBL

SHIFT OPTN (V-Window) F1 (INIT) ESC

F3 (TYPE) 1 (Y=) X,θ,T (X,θ,T + 2) (X,θ,T − 2) EXE

F5 (DRAW)

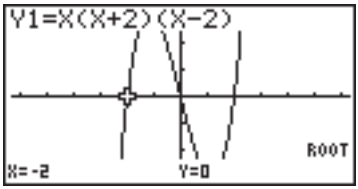
② F4 (G-SLV) 1 (Root)

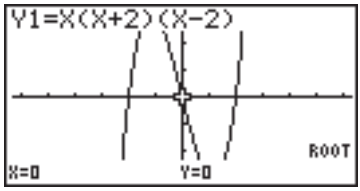
⋮

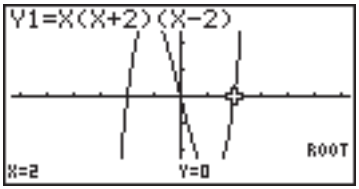
④ ▶

▶

Result Screen







When analyzing a single graph, results appear as soon as you select an analysis function in step 2, so step 3 is not necessary.
Root, maximum value, minimum value, and y-intercept can be calculated for rectangular coordinate graphs and inequality graphs only.
The y-intercept is the point where the graph crosses the y-axis.

■ Calculating the Point of Intersection of Two Graphs

Description

Use the following procedure to calculate the point of intersection of two graphs.

Set Up

1. Draw the graphs.

Execution

2. Press [F4] (G-SLV) [F5] (Isect). When there are three or more graphs, the selection cursor (■) appears at the lowest numbered graph.
3. Use the cursor keys to move the cursor to the graph you want to select.
4. Press [EXE] to select the first graph, which changes the shape of the cursor from ■ to ◆.
5. Use the cursor keys to move the cursor to the second graph.
6. Press [EXE] to calculate the point of intersection for the two graphs.
   When an analysis produces multiple values, press ▶ to calculate the next value.
   Pressing ◀ returns to the previous value.

● ● ● ● ●

Example **Graph the two functions shown below, and determine the point of intersection between Y1 and Y2.**
Y1 = x + 1, Y2 = x^2

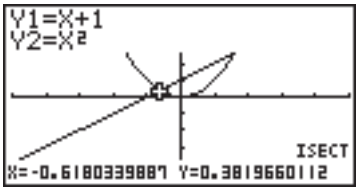
Use the following V-Window settings.

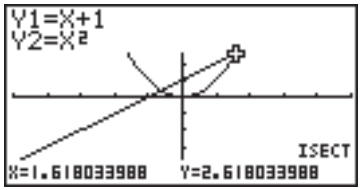
Xmin = –5, Xmax = 5, Xscale = 1
Ymin = –5, Ymax = 5, Yscale = 1

Procedure

① MENU GRPH • TBL
SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 1 EXE ▼
(–) 5 EXE 5 EXE 1 EXE ESC
F3 (TYPE) 1 (Y=) X,θ,T + 1 EXE
X,θ,T x^2 EXE
F5 (DRAW)
② F4 (G-SLV) 5 (Isect)
⋮
⑥ ▶

Result Screen





In the case of two graphs, the point of intersection is calculated immediately after you press F4 5 in step 2.

You can calculate the point of intersection for rectangular coordinate graphs and inequality graphs only.

■ Determining the Coordinates for Given Points

Description

The following procedure describes how to determine the y-coordinate for a given x, and the x-coordinate for a given y.

Set Up

1. Draw the graph.

Execution

2. Select the function you want to perform. When there are multiple graphs, the selection cursor (■) appears at the lowest numbered graph.
   F4 (G-SLV) 6 (Y-Cal) ... y-coordinate for given x
   7 (X-Cal) ... x-coordinate for given y
3. Use ▲ ▼ to move the cursor (■) to the graph you want, and then press EXE to select it.
4. Input the given x-coordinate value or y-coordinate value.
   Press EXE to calculate the corresponding y-coordinate value or x-coordinate value.

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Example **Graph the two functions shown below and then determine the y-coordinate for x = 0.5 and the x-coordinate for y = 2.2 on graph Y2.**
Y1 = x + 1, Y2 = $x(x + 2)(x - 2)$

Use the following V-Window settings.

Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1 (initial defaults)

Procedure

① MENU GRPH•TBL

SHIFT OPTN (V-Window) F1 (INIT) ESC

F3 (TYPE) 1 (Y=) X,θ,T + 1 EXE

X,θ,T (X,θ,T + 2) (X,θ,T − 2) EXE

F5 (DRAW)

② F4 (G-SLV) 6 (Y-Cal)

③ ▼ EXE

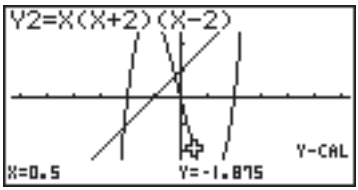
④ 0 • 5 EXE

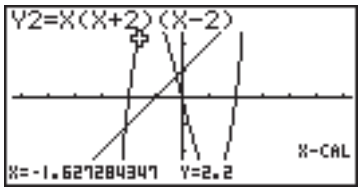
② F4 (G-SLV) 7 (X-Cal)

③ ▼ EXE

④ 2 • 2 EXE

Result Screen





When there are multiple results for the above procedure, press ▶ to calculate the next value. Pressing ◀ returns to the previous value.

Step 3 of the above procedure is skipped when there is only one graph on the display.

The X-Cal value cannot be obtained for a parametric function graph.

After obtaining coordinates with the above procedure, you can input different coordinates by first pressing X,θ,T.

■ Calculating the Integral Value for a Given Range

Description

Use the following procedure to obtain integration values for a given range.

Set Up

1. Draw the graph.

Execution

2. Press F4 (G-SLV) 8 ($\int dx$). When there are multiple graphs, this causes the selection cursor (■) to appear at the lowest numbered graph.
3. Use ▲ ▼ to move the cursor (■) to the graph you want, and then press EXE to select it.
4. Use ◀ to move the lower limit pointer to the location you want, and then press EXE.
   You can also move the pointer by pressing X,θ,T to display the pop-up window, and then inputting coordinates.
5. Use ▶ to move the upper limit pointer to the location you want.
   You can also move the pointer by pressing X,θ,T to display the pop-up window, and then inputting the upper limit and lower limit values for the integration range.
6. Press EXE to calculate the integral value.

When setting the range, make sure that the lower limit is less than the upper limit.

Integral values can be calculated for rectangular coordinate graphs only.

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Example **Graph the function shown below, and then determine the integral value at (–2, 0).**

Y1 = $x(x + 2)(x - 2)$

Use the following V-Window settings.

Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –4, Ymax = 4, Yscale = 1

Procedure

① MENU GRPH • TBL

SHIFT OPTN (V-Window) (–) 6 • 3 EXE 6 • 3 EXE 1 EXE ▼

(–) 4 EXE 4 EXE 1 EXE ESC

F3 (TYPE) 1 (Y=) X,θ,T (X,θ,T + 2) (X,θ,T – 2) EXE

F5 (DRAW)

② F4 (G-SLV) 8 ($\int dx$)

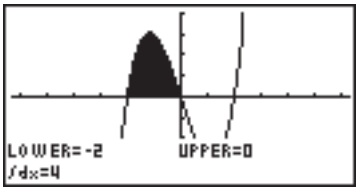
⋮

④ ◀~◀ EXE

⑤ ▶~▶ (Upper limit; $x = 0$)

⑥ EXE

Result Screen



■ Implicit Function Graph Analysis

You can determine approximations of the following analytical results using implicit function graphs.

- Focus/vertex/eccentricity
- Latus rectum
- Center/radius
- x-/y-intercept
- Directrix/axis of symmetry drawing and analysis
- Asymptote drawing and analysis

After graphing an implicit function, press F4 (G-SLV) to display the following graph analysis menus.

• Parabolic Graph Analysis

- {**Focus**}/{**Vertex**}/{**Length**}/{**e**} ... {focus}/{vertex}/{lactus rectum}/{eccentricity}
- {**Dirtrx**}/{**Sym**} ... {directrix}/{axis of symmetry}
- {**X-Icpt**}/{**Y-Icpt**} ... {x-intercept}/{y-intercept}

• Circular Graph Analysis

- {**Center**}/{**Radius**} ... {center}/{radius}
- {**X-Icpt**}/{**Y-Icpt**} ... {x-intercept}/{y-intercept}

• Elliptical Graph Analysis

- {**Focus**}/{**Vertex**}/{**Center**}/{**e**} ... {focus}/{vertex}/{center}/{eccentricity}
- {**X-Icpt**}/{**Y-Icpt**} ... {x-intercept}/{y-intercept}

• Hyperbolic Graph Analysis

- {**Focus**}/{**Vertex**}/{**Center**}/{**e**} ... {focus}/{vertex}/{center}/{eccentricity}
- {**Asympt**} ... {asymptote}
- {**X-Icpt**}/{**Y-Icpt**} ... {x-intercept}/{y-intercept}

The following examples show how to use the above menus with various types of implicit function graphs.

• To calculate the focus, vertex and latus rectum

[G-SLV]-[Focus]/[Vertex]/[Length]

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Example **To determine the focus, vertex and latus rectum for the parabola $X = (Y - 2)^2 + 3$**

Use the following V-Window settings.

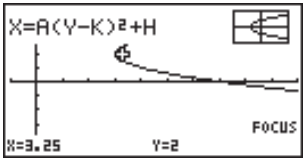
Xmin = –1, Xmax = 10, Xscale = 1

Ymin = –5, Ymax = 5, Yscale = 1

[F4] (G-SLV)

[1] (Focus)

(Calculates the focus.)

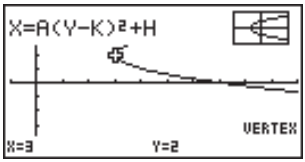


[ESC]

[F4] (G-SLV)

[3] (Vertex)

(Calculates the vertex.)

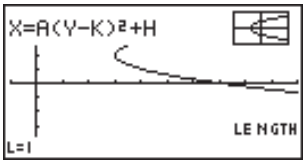


[ESC]

[F4] (G-SLV)

[5] (Length)

(Calculates the latus rectum.)



- When calculating two foci for an ellipse or hyperbolic graph, press ▶ to calculate the second focus. Pressing ◀ returns to the first focus.
- When calculating two vertexes for an ellipse or hyperbolic graph, press ▶ to calculate the second vertex. Pressing ◀ returns to the first vertex.

• To calculate the center and radius

[G-SLV]-[Center]/[Radius]

● ● ● ● ●

Example **To determine the center and radius for the circle $(X + 2)^2 + (Y + 1)^2 = 2^2$**

Use the following V-Window settings.

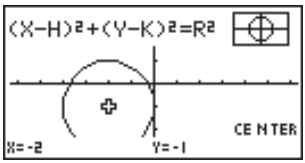
Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1

F4 (G-SLV)

1 (Center)

(Calculates the center.)

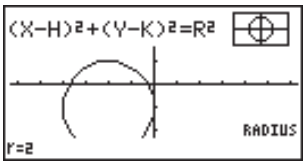


ESC

F4 (G-SLV)

2 (Radius)

(Calculates the radius.)



• To calculate the x- and y-intercepts

[G-SLV]-[X-Icpt]/[Y-Icpt]

● ● ● ● ●

Example **To determine the x- and y-intercepts for the hyperbola**

$$\frac{(X-3)^2}{2^2} - \frac{(Y-1)^2}{2^2} = 1$$

Use the following V-Window settings.

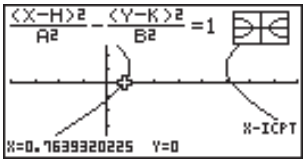
Xmin = –4, Xmax = 8, Xscale = 1

Ymin = –5, Ymax = 5, Yscale = 1

F4 (G-SLV)

6 (X-Icpt)

(Calculates the x-intercept.)

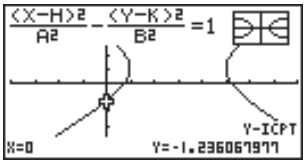


ESC

F4 (G-SLV)

7 (Y-Icpt)

(Calculates the y-intercept.)



- Press ▶ to calculate the second set of x-/y-intercepts. Pressing ◀ returns to the first set of intercepts.

• To draw and analyze the axis of symmetry and directrix

[G-SLV]-[Sym]/[Dirtrx]

● ● ● ● ●

Example **To draw the axis of symmetry and directrix for the parabola $X = 2(Y - 1)^2 + 1$**

Use the following V-Window settings.

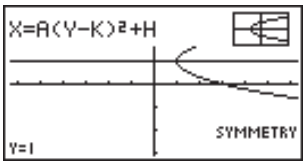
Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1

F4 (G-SLV)

4 (Sym)

(Draws the axis of symmetry.)

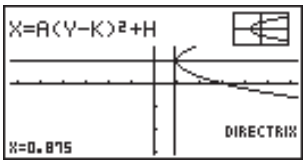


ESC

F4 (G-SLV)

2 (Dirtrx)

(Draws the directrix.)



• To draw and analyze the asymptotes

[G-SLV]-[Asympt]

● ● ● ● ●

Example **To draw the asymptotes for the hyperbola**

$$\frac{(X-1)^2}{2^2} - \frac{(Y-1)^2}{2^2} = 1$$

Use the following V-Window settings.

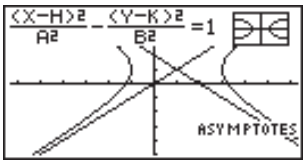
Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –5, Ymax = 5, Yscale = 1

F4 (G-SLV)

4 (Asympt)

(Draws the asymptotes.)



• To calculate eccentricity

[G-SLV]-[*e*]

● ● ● ● ●

Example **To determine the eccentricity of the graph for ellipse**

$$\frac{(X-2)^2}{4^2} + \frac{(Y-2)^2}{2^2} = 1$$

Use the following V-Window settings.

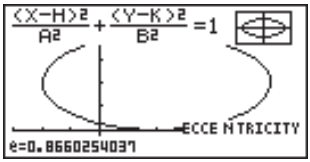
Xmin = –3, Xmax = 7, Xscale = 1

Ymin = –1, Ymax = 5, Yscale = 1

F4 (G-SLV)

4 (*e*)

(Calculates eccentricity.)



Certain V-Window parameters can produce errors in values produced as graph analysis results.
The message "Not Found" appears on the display when graph analysis is unable to produce a result.
The following can result in inaccurate analysis results or may even make it impossible to obtain a solution at all.
— When the solution is tangent to the *x*-axis.
— When the solution is a point of tangency between two graphs.